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PRELIMINARY REPORTS OF PROGRESS - EXPERIMENTAL WATER TREATMENT PLANT II. OPERATING RESULTS, 18-28 JULY 1949

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Oak Ridge, Tennessee

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Oak Ridge National Laboratory

Health Physics Division

Waste Disposal Research Section

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PRELIMINARY REPORTS OF PROGRESS - EXPERIMENTAL WATER TREATMENT PLANT

II. OPERATING RESULTS. JULY 18-28, 1949

Conrad P. Straub, Thomas R. Ostrom, and
K. Stanley Lyle¹

Before studies on the removal of radioactive materials by the experimental water treatment plant described previously² were initiated, it was felt desirable to obtain information relative to the efficiency of the plant in treating raw waters. To obtain these data, the plant was in continuous operation for the period July 18-20 and July 25-28, 1949, except as noted below. During these intervals, turbid waters were treated with alum and alkali, passed through the coagulation and sedimentation chambers, and filtered.

Hourly samples were collected of the raw, mixed, settled, and filtered waters, and the pH, turbidity, and alkalinity were determined.

The results will be reported for the two periods of operation; namely, July 18-20 and July 25-28, respectively.

Operating Results - July 18-20, 1949

On July 18 the plant was operated for a period of 17 hours, on July 19 for 8 hours, and on July 20 for 24 hours.

Tap water run into a 500-gallon wooden tank served as a source of raw water. This water was fed by gravity to the mixing basin where variable quantities of turbidity, alum, and alkali were

¹Respectively, Sanitary Engineer, USPHS, on loan, Waste Disposal Research Section; First Lieutenant, MSC, on loan, Waste Disposal Research Section; and Laboratory Trainee, ORNL, Waste Disposal Research Section.

²Preliminary Reports of Progress - Experimental Water Treatment Plant. I. Description of Experimental Water Treatment Plant. Conrad P. Straub. August 15, 1949.

added from 20 liter carboys through the Harvard pump. Raw water was fed to the plant at rates varying from 213-269 gpd.

The raw water characteristics for this period of operation are given in Table 1.

In the mixing basin, the chemicals and water were subjected to approximately five minutes of rapid agitation by means of a variable speed "Mixmaster" type mixer. Samples of the mixed water were collected at the discharge end of the one-inch diameter effluent line. Analytical results are indicated in Table 1. The alum and alkali (NaOH) dosages were considerably greater than necessary, and should have been in the order of one to two grains per gallon. There was a slight increase in the pH and a greater increase in the alkalinity as compared with the raw water.

Observations were made on the size of the floc in the flocculation basin and upon its settleability in the sedimentation basin, and these showed that, in general, the floc was small and feathery and did not settle very rapidly. In all probability, this was due to operating at pH levels above 7.0, and possibly to the high dosages of chemicals employed.

The settled water characteristics are noted in Table 1. These data show that a 93.1 per cent reduction in turbidity resulted from flocculation and sedimentation.

After passing through the coagulation and settling units, the water was pumped to orifice cups, which served the filters, by the Harvard pump. Filtered water analytical results are shown in Table 1.

Data on the length of filter runs between washings, the per cent of time in operation, and the per cent of wash water used are also presented. These values show that the length of filter run increased with time. This was to be expected as the settled water added to the filters was more satisfactory at the end of the run than it was at the beginning.

The last runs indicated that the left filter was in operation 9.1 hours between washes and the right filter 13.03 hours. The volume of wash water used was abnormally high, as shown by the data in Table 1, but this was due to the long washing times used. Usual practice calls for washing about 3.5 minutes with the volume of wash water used amounting to 2 to 5 per cent of the amount of water filtered.

Approximately 98 per cent of the added turbidity was removed by the plant, and the final turbidity of the filtered water was approximately 3 ppm. The 1942 edition of the U. S. Public Health Service Drinking Water Standards³ states that, "The turbidity of the water shall not exceed 10 ppm (silica scale)." However, the standard set for a filtered water by the South District Filtration Plant, Chicago, is 0.1 ppm turbidity.⁴ On the latter basis, it will be seen that the water did not meet the suggested standard.

A comparison of the raw (tap water) and finished waters shows that there was little difference between the initial and final values in turbidity, alkalinity, and pH, namely: 3.5 and 3.0 ppm, 82 and 77 ppm,

³Reprint No. 2440. Public Health Reports (Vol. 58, No. 3) and Journal, AWWA, 35: 102 (January 1943).

⁴John R. Baylis, Chicago South District Filtration Plant. Journal, AWWA, 41: 612 (July 1949).

and 7.31 and 7.62, respectively. In other words, the plant reproduced the initial tap water by taking out the added turbidity.

Operating Results - July 25-28, 1949

During this period, the plant was operated for 24 hours on July 25, 16 hours on July 26 (the filters were in operation for only 6 hours), 16 hours on July 27, and 24 hours on July 28.

Tap water was again used as a source of raw water and was modified by the addition of turbidity in the form of clay. The variation in the raw water during each day of operation is noted in Table 2. Raw water was fed at an average rate of approximately 250 gpd.

Alum and NaOH were added to the raw water by gravity and the turbidity was added by the Harvard pump. The raw water, NaOH, and turbidity were fed into the 2-inch well of the mixing basin, and the alum was fed at a point just upstream of the one-inch diameter outlet. This was done to conform with statements found in the literature⁵ which noted that the alkali should be added first, and the alum at some point downstream. Mixed water samples were collected at the influent end of the flocculation basin.

The actual dosages of alum, NaOH, and turbidity employed are shown in Table 2. The floc, which resulted from the alum and NaOH dosages indicated for July 25 and 26, was very small and did not settle well, as shown by the analytical values reported in Table 2. A check of

⁵Hopkins, Edward S. Water Purification Control. The Williams and Wilkins Company, Baltimore, Md., 1948. p. 14.

the dosing chemicals uncovered the fact that the alum solution used was unsatisfactory.⁶

Laboratory jar tests were made by Lauderdale⁷ and Straub to establish optimum chemical dosages, and some of these indicated that, in all probability, the NaOH could be dispensed with. When the plant is placed in operation again the NaOH dosage may be omitted. In addition, Lauderdale ran some preliminary jar tests utilizing sodium silicate as a coagulant aid.

Analyses indicated that the settled water had the characteristics noted in Table 2. These results reveal that the water was not flocculated properly during the period July 25-26, inclusive, but, as noted above, this was due to the use of an unsatisfactory alum solution. With the change in alum, flocculation improved, and the floc produced settled more rapidly. The reduction in turbidity through coagulation and settling was rather appreciable (93.8 per cent) when the relatively small dosages of chemicals used are considered⁸ (alum 0.65 gpg, alkali

⁶The alum was prepared and stored in steel drums. Apparently, the alum was modified to such an extent by this procedure that it was unsuitable for coagulant use. Alum is an acid solution and when added to an alkaline water lowers the pH in proportion to the amount added. That this did not occur may be seen from the data reported for July 25, when a rather heavy dose of alum (2.16 gpg) and a small dose of NaOH (0.47 gpg) did not lower the pH of the mixed water but the pH increased. New alum solutions were prepared on July 27, and were stored in glass carboys of approximately 20 liters capacity. Flocculation improved and the floc settled rapidly.

⁷Robert A. Lauderdale, Jr., Associate Chemical Engineer, ORNL, Waste Disposal Research Section.

⁸Hopkins, Edward S. Water Purification Control. The Williams and Wilkins Company, Baltimore, Md., 1948. (See p. 41 - Hazen's curve for turbidity versus alum dosage).

0.24 gpg). Normal practice usually calls for the addition of 1 to 2 gpg of chemicals depending upon the nature and source of the raw water.

Data pertaining to the filtered water and filter operation are also indicated in Table 2.

Overall turbidity removal was very satisfactory, since the filtered water turbidities obtained were not measurable by the instruments available (Lumitron readings permitted determination of the turbidity to about 0.1 ppm). The amounts of wash water used were still high, but these will be reduced as normal operating practices are approached. A comparison of the tap water and the filtered water shows little difference except for the alkalinity values which were lowered after treatment.

Summary and Conclusions

The two trial periods of operation described above indicated that the water treatment plant could produce a very satisfactory effluent without excessive use of alum and alkali.

Further studies should be made at a later date utilizing iron salts for coagulation to determine efficiencies which result from such operation.

Insofar as the plant itself is concerned, the results obtained are in line with those obtainable in normal practice, and the plant may be used in all studies and should provide adequate operating information for translation to pilot plant experiments and perhaps to full scale operation.

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August 16, 1949.

Table 1. Operating Results - July 18-20, 1949

Date	Operation Hrs.	RAW WATER					MIXED WATER					SETTLED WATER				
		Flow gpm	pH	Alkalinity ppm	Turbidity ppm	Temp °C	CHEMICALS ADDED				pH	Alkalinity ppm	Temp. Fahrenheit - ppm	% Reduction	pH	Alkalinity ppm
							Alum gpm	NaOH gpm	Turbidity ppm							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
July 18	17	242.1	7.37	82.0	3.8		6.15	6.51	154.5	7.42	87.4	10.4	94.3	7.43	88.9	
July 19	6	228.3	7.34	79.6	5.5		5.02	6.79	153.8	8.08	134.7	14.6	90.5	8.15	93.4	
July 20	24	249.6	7.25	81.9	2.6	27.2	4.59	4.38	140.8	7.11	103.5	9.9	92.9	7.34	73.2	
Weighted Av.		250.5	7.31	81.6	2.5		5.20	5.35	152.1	7.22	103.0	10.2	93.1	7.51	75.7	

Table 1 (cont'd). Operating Results - July 18-20, 1949

Date	Operation Hrs.	FILTERED WATER															
		LEFT FILTER					RIGHT FILTER										
		Flow Rate MGAD	Turbidity ppm	pH	Alkalinity ppm	No. Times Washed	Hrs. in Op. between Machines (Av.)	% Time in Operation	% Wash Water Used	Flow Rate MGAD	Turbidity ppm	pH	Alkalinity ppm	No. Times Washed	Hrs. in Op. between Machines (Av.)	% Time in Operation	% Wash Water Used
(1)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
July 18	12	111.8	3.3	7.49	71.1	3	2.88	81.3	43.2	93.2	3.2	7.55	71.6	3	2.93	83.4	48.7
July 19	8	119.6	4.5	8.10	89.5	1	2.50	91.7	21.1	102.6	4.2	8.17	86.7	1	3.33	96.8	29.7
July 20	24	117.1	2.3	7.50	75.1	3	5.68	91.7	22.2	95.0	2.4	7.49	73.1	3	7.77	91.7	43.0
Weighted Av.		116.1	3.0	7.61	76.6					95.9	2.9	7.63	75.1				

Table 2. Operating Results - July 25-28, 1949

RAW WATER				MIXED WATER				SETTLED WATER				FILTERED WATER									
Date	Operation Hrs.	Flow GPD	PH	Alkalinity ppm	Turb.(ppm)	Temp. °C	CHEMICALS ADDED				PH	Alkalinity ppm	TURB.		PH	Alkalinity ppm	Operation Hrs.	Flow GPD	Turb.(ppm)	PH	Alkalinity ppm
							Alum GPC	NaOH GPC	CaO GPC	Turbidity ppm			Final ppm	% Reduc-tion							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	
July 25	24	247.8	7.26	74.6	0.2	27.1	2.16	0.47	95.9	7.80	84.2	41.3	57.0	7.66	71.1	19	123.0	0	7.66	70.8	
July 26	16	247.5	7.21	77.4	0	27.8	1.21	1.52	94.2	8.61	102.2	32.2	65.8	8.73	98.7	6	127.8	0	7.81	88.0	
July 27	16	246.0	7.25	78.7	0.4	27.5	0.70	0.42	110.2	7.00	62.2	14.4	87.0	7.09	61.4	16	132.8	0	7.35	65.3	
July 28	24	254.6	7.32	89.4	0	26.8	0.65	0.24	95.5	6.91	63.4	6.0	93.8	6.98	61.8	24	129.5	0	7.30	68.1	
Weighted Av.		249.4	7.27	80.4	0.1	27.2															

Table 2 (con't.) Operating Results - July 25-28, 1949

FILTERED WATER											
LEFT FILTER						RIGHT FILTER					
Date	No. Times Washed	Hrs. in Op.	Washes (Av.)	% Time in Operation	% Wash Water Used	Alkalinity ppm	No. Times Washed	Hrs. in Op.	Washes (Av.)	% Time in Operation	% Wash Water Used
(1)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
July 25	2	9.20	97.3	13.3	100.0	7.64	2	11.00	97.5	14.2	(33)
July 26	1	10.57	96.0	25.0	99.8	8.03	1	7.07	91.7	26.2	(34)
July 27	1	14.07	99.0	16.9	109.1	7.42	1	6.80	98.9	19.6	(35)
July 28	0	2.56	100.0	0	108.5	7.33	1	19.07	98.8	7.4	(36)